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In-Use Performance of Daimler-Benz Light-Duty Diesel Particulate Trap Oxidizers

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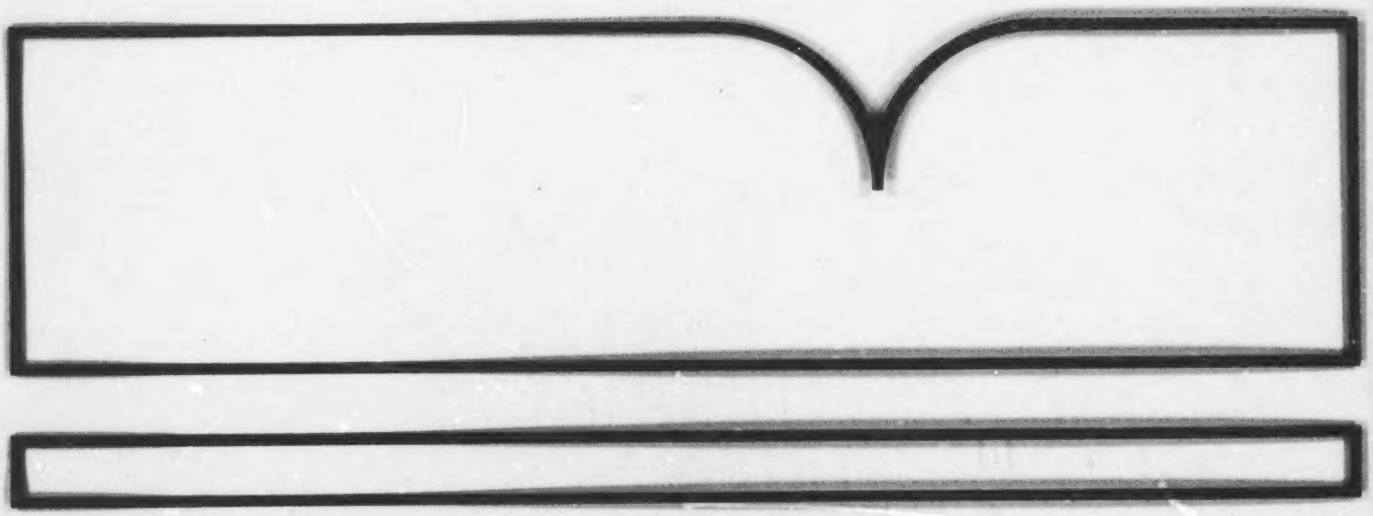

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Technical Report

In-Use Performance of Daimler-Benz Light-Duty Diesel Particulate Trap Oxidizers

By

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and
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February 1988

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16. ABSTRACT

Ten in-use 1985 Mercedes-Benz light-duty diesel vehicles equipped with particulate trap oxidizer systems and with mileages between 30,000 and 50,000 miles were tested for particulate (PM) and gaseous exhaust (HC,CO,CO2, and NOx) emissions. Seven out of ten vehicles had a first-test particulate emission level lower than a predetermined cutoff point of 0.35 g/mi. (The California PM certification standard for 1985 light-duty diesel vehicles is 0.4 g/mi.) Attempts were made to regenerate the particulate trap oxidizers on the three vehicles which exceeded the 0.35 g/mi PM level and the vehicles were retested. Two of three retested vheicles passed the PM cutoff level. The particulate trap oxidizer was removed from the vehicle which still exceeded the PM cutoff level and it was shipped to the vehicle's manufacturer, Damiler-Benz for further analysis.

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In-Use Performance of Daimler-Benz Light-Duty Diesel Particulate Trap Oxidizers

Abstract

Ten in-use 1985 Mercedes-Benz light-duty diesel vehicles equipped with particulate trap oxidizer systems and with mileages between 30,000 and 50,000 miles were tested for particulate (PM) and gaseous exhaust (HC, CO, CO_2, and NOx) emissions. Seven out of ten vehicles had a first-test particulate emission level lower than a predetermined cutoff point of 0.35 g/mi. (The California PM certification standard for 1985 light-duty diesel vehicles is 0.4 g/mi.) Attempts were made to regenerate the particulate trap oxidizers on the three vehicles which exceeded the 0.35 g/mi PM level and the vehicles were retested. Two of the three retested vehicles passed the PM cutoff level. The particulate trap oxidizer was removed from the vehicle which still exceeded the PM cutoff level and it was shipped to the vehicle's manufacturer, Daimler-Benz, for further analysis.*

Introduction

Particulate emissions from light- and heavy-duty diesel engines are of great interest to EPA for both environmental and health reasons. Because of the concerns associated with diesel particulate emissions, EPA has promulgated tighter particulate standards for light-duty diesel vehicles, and more recently, for heavy-duty diesel engines. To comply with these new standards, manufacturers may need to use particulate trap oxidizers.

Until relatively recently, experience with trap oxidizers has largely been confined to information from laboratory testing supplemented by a very limited number of higher mileage durability programs. This has left an information void with regards to this important diesel particulate emission control

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* MBNA has indicated to EPA that it is MBNA's opinion that the program was designed to evaluate only the performance of trap oxidizers and not include concurrent influences such as improper maintenance or isolated manufacturing defects. This contrasts with EPA's position that in-use maintenance and manufacturing variabilities should be included when analyzing the in-use performance of trap oxidizers. The EPA acknowledges MBNA's position. The only question from EPA's perspective is the appropriate weighting factor to be assigned to the individual data points, as discussed in the "Discussion" section.

technology. For example, more information from high mileage traps is needed in the area of mechanical durability (especially for relatively brittle materials such as the ceramic wall flow monolith substrate), catalyst poisoning due to sulfur or other compounds, ash plugging and other failure modes. One source of this type of information would be to test vehicles from a large fleet of trap equipped vehicles such as production vehicles. However, until recently, no production vehicles have been equipped with particulate trap oxidizers. In 1985, Daimler-Benz introduced particulate trap oxidizer systems on their 300D, 300CD, 300SD and 300TD Mercedes-Benz vehicles (engine family FMB3.0D9KC20) in the western states served by the Mercedes-Benz California import facility.

EPA contacted Mercedes-Benz of North America to propose a cooperative program to assess the in-use performance of particulate trap oxidizers. The final agreement which resulted from this proposal included participation from EPA, California Air Resources Board (CARB), Mercedes-Benz of North America (MBNA), and Daimler-Benz Aktiengesellschaft (DBAG). In general terms, MBNA agreed to procure the in-use vehicles on loan from their owners, CARB agreed to test the vehicles and DBAG agreed to provide engineering support. A complete copy of the agreement is contained in Appendix A. The purpose of this report is to present both the details of this program and the test results.

Experimental Details

Test Vehicles - The procurement of the vehicles was performed by MBNA. They acquired a list of all vehicles from EPA Certification Engine Family FMB3.0D9KC20 (M-B models 300D, 300CD, 300SD and 300TD) for model year 1985 which were sold from three dealerships (none of which were owned by DBAG or MBNA) located within 30 miles of the Carson, California MBNA vehicle preparation center. From this list of 852 vehicles, every fourth one was selected (a total of 213 vehicles) and a solicitation letter (a copy of which is in Appendix B) was sent to the owner. Fifty persons responded as being willing to participate in the program. Of these 50, 16 vehicles were identified as being within the target mileage range of 30,000 to 50,000 miles and as never having used diesel-fuel additives not authorized by Mercedes-Benz. (The fuel additive selection criterion was part of the basic program agreement and compliance with it was determined by reviewing the questionnaire which accompanied the solicitation letter.) EPA then randomly ordered the 16 available vehicles for procurement, from which MBNA procured 10 vehicles. One owner later refused to participate in this program when contacted by MBNA and the owner of the eleventh identified vehicle was then contacted. The vehicle information for the 10 vehicles included in this program is presented in Table 1.

Table 1

1985 Mercedes-Benz Light-Duty Diesel Trap Oxidizer
Test Program Vehicle Information

Test Vehicle I.D. Number	Vehicle Model	VIN	Engine Number	Odometer* (miles)
1	300 D	1231331A225300	61795212093728	36444
2	300 D	1231331A251352	61795212103206	49948
3	300 SD	1261251A117247	61795112671387	33462
4	300 D	1231331A229753	61795212095851	35159
5	300 SD	1261201A119072	61795112071582	33849
6	300 D	1231331A257615	61795212106241	32743
7	300 D	1231331A231890	61795212096212	33450
8	300 SD	1261201A138038	61795112071569	34077
9	300 D	1231331A189535	61795212085531	35470
10	300 D	1231331A242239	61795212099776	36056

* Upon check-in at Mercedes-Benz dealership.

Upon receipt of the vehicles at MBNA's dealership, MBNA was allowed to reject a vehicle for any of the following reasons:

1. Insufficient operating fluid levels,

2. Obvious abuse or misuse of the vehicle evidenced by vehicle damage or information from maintenance records,

3. Mileage of vehicle could not be verified,

4. Obvious tampering on the emission control system, or

5. Obvious usage of unauthorized diesel fuel additives (which was also a pre-selection criterion).

None of the vehicles were rejected by MBNA upon receipt for any of the above reasons.

Upon acceptance of the vehicle at the dealership, the vehicle was driven to MBNA's vehicle preparation center. MBNA recorded essential vehicle information and made checks of the electrical system, exhaust system, and transmission. The fuel tank was drained and filled with certification test diesel fuel and was then driven to the CARB test facilities over the same route as for "Title 13" testing purposes. "Title 13" is a California enforcement program designed to check production line vehicles for compliance with California emissions standards. A copy of the MBNA fuel properties is included in Appendix C as well as the "Title 13" road route.

Upon arrival, CARB visually and functionally inspected the vehicle to assure the integrity of the following items:

1. Tires
2. Brakes
3. Exhaust System
4. Cooling System
5. Drive Train
6. Electrical System
7. Transmission
8. Emission Control System (check for obvious tampering)

If CARB deemed the vehicle safe for testing, as all the vehicles were, the rear wheels of the vehicle were replaced with slave tires to prevent the stress of dynamometer testing on the vehicle owner's tires.

Test Procedure - All ten of the vehicles were tested under the following federal test procedures:

1. Fuel drain and fill. A copy of the fuel properties is included in Appendix C.

2. Preconditioning cycle (40 CFR Part 86.132-82 (a)(2)).

3. Soak (40 CFR Part 86.132-82 (b)).

4. Cold FTP (40 CFR Part 86.135-82 through 86.137-82).

5. EPA Highway Fuel Economy (40 CFR Part 600 Subpart B).

If the test was not voided for test procedural reasons and the vehicle's particulate emission rate results did not exceed 0.35 g/mi, the vehicle was returned to MBNA. The 0.35 g/mi particulate emission rate cut point was specified by DBAG. (If a vehicle failed to meet HC, CO, or NOx emissions standards, it was MBNA's intention to repair the vehicle to bring it into compliance with the certification standards before releasing the vehicle back to the owner.) If the test was voided for procedural reasons, the entire test sequence was completed before a second test sequence was started. Finishing the test sequence is required to obtain comparable trap oxidizer loading levels prior to the start of a test sequence.

Vehicles which exceeded 0.35 g/mi PM were to be subjected to the following analytical procedure:

1. Back pressure in front of the trap oxidizer was measured.

2. Vacuum for EGR and air bypass valve were checked.

3. Vehicle was driven in an attempt to regenerate the particulate trap oxidizer.

4. Restorative maintenance activities were carried out by a DBAG representative if it was believed such actions would reduce engine out PM.

The vehicle was retested under the same federal test procedures explained earlier. If the foregoing measures did not result in lowering the PM emission below 0.35 g/mi, the trap oxidizer was replaced by DBAG with a new trap oxidizer. The removed trap oxidizer underwent further analysis by DBAG.

All of the testing followed this predetermined sequence except for vehicle 9. During the initial testing of this vehicle, it was observed that the flow rate through the particulate sampler dropped below the five percent variance limit specified by the Federal Test Procedure, thus voiding the test. The testing was finished and the data processed nevertheless. The unofficial particulate results were 0.41 g/mi, which indicated a problem with the vehicle.

An analysis of the test vehicle by DBAG confirmed a vehicle EGR system malfunction which had been identified by MBNA during the initial vehicle inspection. This malfunction was caused by an intermittent contact of a pin in the plug connecting the coolant temperature sensor to the microprocessor because the pin was not fully pushed into its socket. (MBNA feels that this probably occurred during vehicle assembly.) Without a temperature signal, there is no EGR valve opening and no EGR flow to the engine. Although this malfunction was noted by DBAG prior to testing, the agencies (EPA and CARB) determined that testing would be conducted to determine its impact.

After the initial testing of vehicle 9, the pin was pushed into its socket and the connection was found to work properly. However, with the pin thus repaired, the vehicle was no longer in the desired "as received" condition. Since it was judged impractical to try to simulate an intermittent problem, it was decided to test the vehicle one time with the temperature sensor connected and one time without the temperature sensor connected. The emission results so generated would then represent the range between which the vehicle probably operated when it had the intermittent pin contact problem.

Vehicle 9 failed the particulate criterion on its second test with the temperature sensor connected. Vehicle 9 passed the particulate criterion on the third test with the temperature sensor disconnected. An attempt was made to regenerate the trap by driving the vehicle on the road and vehicle 9 was then tested a fourth time with the temperature sensor connected.

Experimental Results

Of the 10 vehicles tested, seven vehicles had first-test particulate results below the 0.35 g/mi criteria level and three were above the criteria level. Upon trap regeneration and retesting, two of the three vehicles which initially exceeded the particulate criteria level, were retested and the results were below the 0.35 g/mi criteria level. The one remaining failing vehicle had its trap replaced by DBAG and the trap was sent to Germany for analysis.

To further break down the same particulate data, three of the 10 vehicles had first-test results of 0.10 g/mi or less, six vehicles had first-test results of 0.20 g/mi or less and nine of the vehicles had first-test results of 0.40 g/mi or less. All of the particulate data are presented in Table 2.

Of the 10 vehicles tested, two had first-test HC emissions greater than the 0.46 g/mi HC level to which they were certified. None of the vehicles had first-test CO or NOx

Table 2

Vehicle Test Results

Test Vehicle I.D. Number	Test Number	Test Date	Odometer (Miles)[1]	Emissions, g/mi PM	HC	CO	CO_2	NOx	HWFET (MPG)
1	1	4/22	36518	0.24	0.18	2.3	443	0.9	27.2
2	1	4/22	50023	0.08	0.26	1.9	449	0.9	27.4
3	1	4/23	33549	0.10	0.41	1.8	435	0.9	28.6
4	1	4/29	35240	0.18	0.26	2.9	454	0.8	27.0
5	1	4/29	33932	0.38	0.23	1.6	425	0.9	29.6
5	2	5/1	33975	0.33	0.22	1.6	426	0.9	29.7
6	1	4/30	32814	0.49	> 0.49[2]	6.0	480	0.7	25.2
6	2	5/1	32854	0.22	0.22	1.3	467	1.2	27.3
7	1	5/5	33522	0.09	0.29	2.9	441	0.8	25.8
8	1	5/5	34150	0.12	> 0.46[2]	4.1	430	0.8	27.7
9	1[3]	5/6	-	-	-	-	-	-	-
9	2[4]	5/8	35602	0.40	0.25	1.6	463	1.0	27.1
9	3[5]	5/12	35640	0.29	0.18	1.1	445	1.7	28.9
9	4[4]	5/13	35684	0.40	0.29	1.5	453	0.9	27.3
10	1	5/12	36130	0.14	0.26	1.9	451	0.9	26.8
(CA Certification Standards)				0.4	0.46	8.3	-	1.0	-
Mean of All Tests[6]				0.22	0.31[7]	2.7	447	0.9	27.2
Standard Deviation[6]				0.15	0.11[7]	1.4	16	0.1	1.3

1 Mileage at start of test.
2 Exceeded range of measurement.
3 Test voided because the flow rate tolerance was exceeded in bags 1 and 2.
4 Temperature sensor was connected.
5 Temperature sensor was disconnected.
6 The mean and standard deviation are based on only the first valid test of each vehicle.
7 The HC values of 0.49 and 0.46 g/mi were used for vehicles 6 and 8, respectively, in calculating the mean and standard deviation.

levels in excess of the level to which they were certified. These data are also summarized in Table 2. The complete set of emission test output from CARB for each vehicle are presented in Appendix D along with the injection time and engine idle speeds which were taken after the emissions test procedure was completed.

The emission results of the retested vehicles which did not pass the predetermined cut-off level of 0.35 g/mi particulate are also contained in Table 2. The particulate from both vehicles 5 and 6 dropped below the 0.35 g/mi level upon retesting, however, vehicle 9 remained above 0.35 g/mi. The particulate from vehicle 5 decreased from 0.38 g/mi to 0.33 g/mi, and the particulate from vehicle 6 decreased from 0.49 g/mi to 0.22 g/mi.

Table 3 is a summary of the repairs which were made to the three vehicles that exceeded the predetermined cut-off level of 0.35 g/mi particulate. The trap back pressure, EGR vacuum, and air bypass measurements are also presented in Table 3. The trap back pressure was taken between the first and second tests. However, vehicles 5 and 6 were driven about three miles prior to the trap back pressure test. The short drive, which consisted of heavy accelerating and braking, is likely to have affected the condition of the particulate trap oxidizer and thus the back pressure measurement on vehicles 5 and 6. Vehicle 6 had thick, black oil in the fuel injection pump. The oil was drained and was replaced during the subsequent vehicle operation. (Vehicle 6 had only had three oil changes instead of the recommended seven oil changes. See Table 3, footnote 2.) The air filter was removed, cleaned and reinstalled on vehicle 6, also. Based on its service record, DBAG feels that vehicle 6 is not representative of the vehicle population utilizing trap oxidizers. It was tested, however, to see what the effect of such in-use lack-of-maintenance is in terms of emissions.

Discussion

The objective of this program was to acquire data on trap durability. In this regard, a few observations can be made. Of the 10 vehicles tested, there were no gross trap failures, since none of the vehicles exceeded the California particulate standard level of 0.4 g/mi except one, and it passed after maintenance and trap regeneration. Yet such an observation could mask some underlying problems. The 50,000 mile certification test results (low mileage plus deterioration) were 0.12 g/mi particulate for the 300 D and 300 CD and 0.14 g/mi particulate for the 300 TD and 300 SD. Thus, it would be reasonable to expect that vehicles would emit less than about 0.15 g/mi particulate at the average 36,000 miles at which these vehicles were tested. Yet on the first test, only five

Table 3

Repairs Made to Failing Test Vehicles and Back Pressure, EGR Vacuum and Air Bypass Measurements (bar)

Vehicle Number	Actions Taken/ Repairs Made to Vehicle	Back Pressure	EGR Vacuum	Air Bypass
5	- Vehicle driven 2-3 miles[1]	0.75	0.30	0.70
6	- Vehicle driven 3-4 miles[1]	0.65	0.29	0.72
	- Black, thick oil drained out of injection pump[2] (approx. 3/4 cup)			
	- Dirty air filter was cleaned and reinstalled			
9	- Plug to coolant temperature sensor was reconnected[4]	0.65[3]	0.27[3]	0.75[3]
	- Vehicle driven about 6 miles[1,4]	0.80[4]		

1 On-Road driving consisted of heavy acceleration and breaking.
2 Vehicle 6 had only had three oil changes (at 2439, 11978, and 20825 miles) instead of the seven recommended oil changes at 1000, 5000, 10000, 15000, 20000, 25000, and 30000 miles.
3 After second test.
4 After third test.

vehicles had particulate emissions at such a low level. This could indicate some level of trap failure.

It has been reported that gasoline-fueled vehicle ceramic monolith catalysts frequently undergo some level of mechanical failure. Yet there is sufficient mechanical structure remaining to give good catalytic activity, even at high mileages. The same thing may be occurring with these traps. The traps are made of basically the same material - i.e., honeycomb cordierite. The results of this program seem to point to mechanical failure in that five of the vehicles had particulate emissions exceeding 0.15 g/mi. This thought is further bolstered by the results from vehicle 9, which was tested with and without the temperature sensor connected. With the temperature sensor connected, the EGR should function properly, giving lower NOx emissions and higher engine-out particulate emissions (about 0.55 g/mi for this vehicle according to MBNA). With the temperature senor disconnected, the EGR will not function properly, resulting in higher NOx and lower particulate. In reviewing the data one sees that the temperature sensor did have the predicted influence on NOx - i.e., no EGR led to high NOx and visa versa. However, the trap-out particulate emissions changed in the same direction as the engine-out particulate emissions. If the trap oxidizer was mechanically intact, little change in trap-out particulate emissions should have been seen from a change in engine-out particulate levels. But since trap-out particulate emissions did change by an appreciable amount as a function of engine-out emissions it would indicate some mechanical failure of the trap.

The other observation that can be made about the trap oxidizer is its usefulness as an aftertreatment device to meet various emissions standards. The Federal emission standards are 50,000 mile standards which combine low mileage emission results with deterioration factors to project a 50,000 mile emission rate which must be below the standard. The vehicles which were tested in this program should have had particulate emissions below the emission standard to which they were certified, since they had not reached 50,000 miles (with one exception). Thus, for a 0.4 g/mile particulate standard, all but one of the vehicles were at or below the standard level. (One poorly maintained vehicle exceeded the 0.4 g/mi standard level but was tested below this level after maintenance and trap regeneration.)

However, the testing took place at about 36,000 miles and not 50,000 miles. If there is additional deterioration in the emissions behavior of these vehicles, then by 50,000 miles some of the vehicles may fail the 0.4 g/mi standard.

The emission control system employed by DBAG for the Mercedes-Benz vehicles tested was designed specifically for those vehicles' engines and for 0.4 g/mi particulate standard.

Never-the-less, some have considered the particulate trap-oxidizer system employed by DBAG to be an appropriate technology for a 0.2 g/mi particulate standard as well. This is due in part to the fact that the DBAG 50,000 mile certification particulate results were 0.14 g/mi or less, which is considerably lower than a 0.2 g/mi standard level. However, at the test mileage of about 36,000 miles, only 7 of the 10 vehicles had particulate at or below 0.2 g/mi. This indicates the possibility of excessive in-use deterioration which would have to be remedied to make this technology usable for a 0.2 g/mi particulate standard.

The above discussion focused on the number of vehicles whose first-test particulate results were above or below a certain level and did not differentiate between vehicles of various maintenance levels, completeness of assembly at manufacture or other such variables. Thus, the results from each vehicle were evaluated on a equal basis, or weighting (i.e., 0.1). This was done because the sample was, with some constraints, randomly chosen and such a sample selection process is based on the assumption that the resultant data will be representative of the whole population.

Some would argue that not all of the vehicles are in fact representative of the whole population at a weighting factor of 0.1, but rather some vehicles (for example, a poorly maintained vehicle) should have a weighting factor of less than 0.1. EPA has no data upon which to assign a weighting factor of other than 0.1, but others may have such data. For their purposes they may want to assign different weighting factors to the vehicle data.

MBNA has indicated to EPA that it is MBNA's opinion that the program was designed to evaluate only the performance of trap oxidizers and not include concurrent influences such as improper maintenance or isolated manufacturing defects. This contrasts with EPA's position that in-use maintenance and manufacturing variabilities should be included when analyzing the in-use performance of trap oxidizers. The EPA acknowledges MBNA's position. The only question from EPA's perspective is the appropriate weighting factor to be assigned to the individual data points, as discussed in the previous paragraph.

Conclusions

The following conclusions can be drawn from this project:

- MBNA and DBAG were cooperative and technically thorough in the vehicle acquisition portion of the program.

- CARB's El Monte test facility appeared to do a technically correct job of testing these vehicles.

- There appeared to be indication of mechanical failure in a portion of the traps on the vehicles tested.

- Relative to the 0.4 g/mi particulate standard to which the vehicles were certified, nine vehicles had first-test emission results below this level. However, the tests took place at about 36,000 miles and if additional trap performance deterioration is experienced, more vehicles will probably exceed the 0.4 g/mi particulate level if they were to be tested at 50,000 miles.

- The trap system used by DBAG was designed specifically for the 1985 model year Mercedes-Benz vehicles and a 0.4 g/mi particulate standard. Never-the-less, the certification particulate test results for these vehicles were 0.14 g/mi or less. The has lead some to conclude that this technology would be appropriate for a 0.2 g/mi particulate standard. However, at about 36,000 miles, only 7 of the 10 vehicles tested had particulate emission levels at or below 0.2 g/mi. Thus, deterioration of this emission control system will have to be controlled to enable it to meet a 0.2 g/mi particulate standard.

Appendix A

Original Cooperative Agreement Between EPA, CARB, MBNA and DBAG

A 2

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February 18, 1987

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Subject: In-Use Testing of Trap Oxidizer Equipped LD Diesel Vehicles

Gentlemen:

In accordance with recent discussions and correspondence with MBNA regarding the above referenced test program, we would like to propose the following program outline to EPA and CARB:

A. General Program Definitions

1. The test program is a cooperative effort between EPA, CARB, MBNA and DBAG.

2. Test data derived from this program will not be used directly as the basis for any emission related recall activities.

3. MBNA will be responsible for vehicle procurement and shipment to and from the CARB test site.

4. CARB will be fully responsible for the vehicles while at the CARB test site.

5. EPA and CARB will be responsible for carrying out the emissions testing of these vehicles and will share all data derived from these tests with MBNA and DBAG.

B. Detailed Program Outline:

1. The program is designed to sample and test in-use PM emissions of Daimler-Benz light-duty diesel vehicles equipped with the Engine Family FMB3.0D9KC20 trap oxidizer system.

   Ten randomly selected vehicles equipped with Engine Family FMB3.0D9KC20 (MY 85) and a mileage between 30,000 and 50,000 miles will be made available by MBNA for this purpose.

2. MBNA will solicit participation of owners for this program through a mail-out. The customers to whom the mail-out will be sent will be chosen as follows. MBNA will identify all purchasers of MY 85 Engine Family FMB3.0D9KC20 from three dealerships in the Los Angeles area. After compiling this list in a random order, MBNA will send a letter to the first 150 customers soliciting their participation and outlining incentives for participation. MBNA will offer limited incentives (appropriate loaner cars, full tank, etc.) to insure a sufficient supply of appropriate vehicles. Every effort will be made, however, to acquire the randomly selected vehicles once identified and in-line with the foregoing incentives. When positive responses to the MBNA letter have been received, MBNA will review the responses in the same order as randomly arranged originally in an attempt to obtain the 10 test vehicles. If 10 test vehicles are not obtained from this first group of letters, additional mail-outs following this same procedure will be undertaken until 10 vehicles are available. A complete record of contacts with customers will be maintained by MBNA.

3. To limit the expenses of vehicle procurement, approx. 2-3 vehicles will be scheduled per week. The duration of the program should not exceed 5 weeks.

4. The in-use test vehicles will be delivered to MBNA dealerships by their owners or representatives. Prior to acceptance of these vehicles they will be visually inspected by MBNA personnel or their representatives. Any cars showing obvious mistreatment will be rejected at the dealership and will not participate in the test program.

Reasons for rejection are:

- Insufficient operating fluid levels (i.e. engine oil level above or below maximum/minimum marker on dipstick),
- Obvious abuse or misuse of vehicle evidenced by vehicle damage or information from maintenance records,
- Mileage of vehicle cannot be verified (i.e. odometer disconnected or replaced).
- Obvious tampering on emission control system (e.g. removed or disabled emission control devices, disconnected vacuum lines and/or electrical connections).
- Obvious usage of unauthorized diesel fuel additives.

MBNA will keep complete records regarding all vehicles inspected and the basis for any vehicle being rejected.

5. EPA and CARB will attempt to return the vehicles to MBNA at the CARB test facility within five working days after receipt of the vehicle.

6. After acceptance of the vehicle by MBNA at its dealership, it will be driven by MBNA personnel or their representatives to MBNA's vehicle preparation center and the following activities will be performed:

   - Recording of essential vehicle information (model type, VIN, engine no., mileage, maintenance records, etc.),
   - Functional check of electrical system (switches, battery, pre-glow system),
   - Visual check of exhaust system for leakages,
   - Functional check of transmission (i.e. shift points).
   - The vehicle tank will be drained and filled with certification diesel fuel. Fuel samples from the vehicle tanks will be taken for later analysis if necessary. In addition, one sample of the certification fuel will also be taken.

This procedure should ensure that the fuel system is properly conditioned with diesel fuel of known quality prior to emission testing.

EPA and/or CARB personnel are invited to observe these activities if so desired.

7. The vehicles will then be driven on the road (same route as used for Title 13 purposes) by MBNA personnel or their representatives to the CARB emission test facility and delivered to EPA/CARB personnel.

   Upon delivery the rear wheels of the vehicle will be replaced with slave wheels and tires to prevent the stress of dynamometer testing from the customer's tires. Slave wheels and tires will be supplied by MBNA.

8. EPA/CARB will perform one routine test sequence consisting of:

   fuel drain and fill
   preconditioning cycle
   soak
   cold FTP 78
   HWFET.

   If the test results are not voided for test procedure reasons and the vehicles do not exceed 0.35 g/m PM, the vehicle will be returned to MBNA personnel. If a test is void, the test sequence will be finished before a 2nd test sequence is started. No retesting will be performed on a vehicle if the only reason for a test failure is that the vehicle exceeds emission standards for HC, CO, or NOx.

9. MBNA will have no obligation to adjust and/or repair any vehicles, even if they failed in one or more emission constituents. However, it is the intention of DBAG to bring all vehicles into specification before returning them to their owners. Records regarding any MBNA actions in this respect will be available to review by EPA and/or CARB.

10. Vehicles exceeding a PM value of 0.35 g/mi as a result of a FTP-78 test will be subjected to the following analytical procedure:

    - Test back-pressure in front of TO,

    - Check vacuum for EGR and air bypass valve.

- In case the back-pressure level exceeds the Service Manual limit of 1.3 bar at 4,000 rpm (high idle, gear shift lever in "P" position) an attempt will be made to regenerate the trap by driving an appropriate cycle on the dynamometer or highway. In addition, restorative maintenance activities will be carried out by DBAG if it believes such actions would reduce engine out PM emissions.

- If the foregoing measures do not result in the PM emissions of the vehicle being below 0.35, the TO will be replaced with a new TO by and at the expense of DBAG and sent to DBAG for further analysis.

11. TOs sent to DBAG for further evaluation will receive one or more of the following checks as deemed appropriate:

    - Initial visual inspection,

    - Removal of insulation shells and partial regeneration in an oven at 750 degrees C.

    - Alternatively the TO might be installed on an engine and operated on an engine test stand at full throttle for 15 min.

    - Back pressures will be measured under laboratory conditions before and after all regeneration procedures.

    - Finally the filter might be cut open to perform in-depth analysis consisting of:

        ° Visual examination under a microscope,

        ° X-ray fluorescence spectroscopy,

        ° Qualitative and quantitative analysis with respect to ashes found in the TO cells,

        ° Mechanical testing of substrate,

        ° Examination of the structure of welding seams.

12. A summary of these findings will be provided to EPA and CARB.

We would appreciate your review of the foregoing test program. If you agree with the provisions noted above, please sign a copy of this letter and send it to me. As soon as all parties have signed indicating agreement on the program, it will take MBNA approximately 6-8 weeks to organize vehicle procurement.

Sincerely yours,

Harald Polz, Manager
Emission Control

HP/jl

Agreed to:

_____ Date: _____
Charles Gray for
Environmental Protection Agency

_____ Date: 2/19/87
Tom Cackette, for
California Air Resources Board

_____ Date: 2/23/87
K.D. Drachand, for
California Air Resources Board

Appendix B

Vehicle Solicitation Letter Sent by MBNA to Vehicle Owners

February 1987

Dear Mercedes-Benz Owner:

Mercedes-Benz of North America is participating in a joint program with the Environmental Protection Agency and the California Air Resources Board to obtain valuable information for engine research and development, and to help the agencies in evaluating present and future emission control strategies.

We invite you to participate in this program by filling out the attached questionnaire at your earliest convenience and returning it to:

Mercedes-Benz of North America
1 Mercedes Drive
Montvale, N.J. 07645

Attn: Product & Service Engineering

as indicated on the addressed and stamped envelope enclosed.

The information we receive will be checked against certain key criteria needed for this program and all vehicles meeting these requirements will be eligible for a random drawing determining the participants.

If your vehicle is selected in the random drawing, one of our local Zone representatives will get in touch with you to make all necessary arrangements. You will then bring your car to a local MB dealership, where we will provide you with a current model year Mèrcedes-Benz loaner car free of charge to you. When you receive your car back it will be washed and have a full tank of fuel. In addition, the next scheduled major service on your vehicle performed at an authorized MB dealership will also be free of charge.

While in the program, your car will be tested on a vehicle dynamometer at the California Air Resources Board and MBNA labs. We anticipate that the tests and measurements will take about 5-10 business days and we anticipate that less than 250 miles will be added to your car by the program. All parts and labor required during these tests will be free of charge to you. You will only be required to sign an authorization form permitting representatives of MBNA, EPA and the CARB to drive and test the car and replace any part deemed necessary to perform the task of the program.

Please be assured that our technicians will handle your car with utmost care. Further, Mercedes-Benz of North America will assume responsibility for the condition of your car while it is in our custody.

We appreciate your help in conducting this program. If there are any questions regarding the program, please contact Mr. Carl Partyka, Los Angeles Zone, Telephone #213-835-8315. Thank you for your assistance and we look forward to receiving your questionnaire.

Sincerely,

Appendix C

Properties of Test Program Fuel and "Title 13" Driving Route

Laboratory Test Report

PHILLIPS 66 COMPANY
A SUBSIDIARY OF PHILLIPS PETROLEUM COMPANY

BARTLESVILLE, OKLAHOMA 74004

D-2 DIESEL CONTROL FUEL

LOT G-668

Test	Results	EPA Specification*	Test Method
Cetane Number	45.8	43 - 47	D 613
Distillation Range, °F			
IBP	353	345-375	D 86
5%	407		
10	424	400-440	
20	450		
30	470		
40	488		
50	504	495-525	
60	522		
70	541		
80	563		
90	592	580-610	
95	623		
DP	639		
EP	641	630-660	
Oxidation Stability, mg/100ml	0.71	1.5 Max.	
Gravity, °API	35.4	33 - 36	D 287
Total Sulfur, WT%	0.36	0.2-0.4	D 3120
Aromatics (FIA), Vol%	34.2	29 - 35	D 1319
Kinematic Viscosity, cs	2.5	2.2-3.2	D 445
Flash Point (PM, °F)	161	130 Min.	D 93
Particulate Matter, mg/l	1.5	15 Max.	D 2276
Cloud Point, °F	+10	15 Max.	
Pour Point, °F	+ 5		
Corrosion	1	3 Max.	
Net Heat of Combustion, BTU/lb	19,250		
Carbon Density, grams carbon/gal.	2,778	2750-2806	
Cetane Index	46.9	43 - 47	

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EMISSION TEST LABORATO

30 ptb of Du Pont FOA #11 antioxidant enhances the stability of this fuel.

*Diesel Fuel as described in Chapter One-Environmental Protection Agency, subsection 86.113-78, of the Federal Regulations.

Table C-1

"Title 13" Vehicle Route Description from Mercedes-Benz to CARB

Bonita Street	N	0.2 miles
223rd Street	E	0.8 miles
405 Freeway	S	3.6 miles
7 Freeway	N	3.5 miles
91 Freeway	E	5.0 miles
605 Freeway	N	15.5 miles
10 Freeway	W	4.0 miles
Rosemead Blvd.	S	0.2 miles
Telstar Ave.	E	0.6 miles
Total Mileage		33.4 miles

Appendix D

Detailed Emissions Test Output from CARB

Due to the large amount of paper associated with the vehicle tests, the complete results are not included with this report. If it is necessary to obtain a copy of the complete results, they are available from EPA. Please phone Thomas Baines at (313) 668-4366 for further information.

Table D-1

Injection Time and Engine Idle Speed of Test Vehicles

Vehicle I.D. Number	Injection Time (degrees)	Engine Idle Speed (rpm)
1	23.5	710
2	24.0	720
3	24.0	710
4	24.0	720
5	23.0	700
6	24.0	720
7	24.0	730
8	22.5	720
9	24.5	800
10	24.5	705